

"Quantifying surface fluxes in the ice-covered polar oceans using microwave satellite data"

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Satellite passive microwave sea ice data records extending > 20 years have become an important proxy for climate variability. More importantly, in the 1990's these data have been exploited in conjunction with new fine resolution satellite image datasets originating from ERS-1/2, and RADARSAT Synthetic Aperture Radar (SAR), and medium resolution ERS-1/2 and NSCAT radar scatterometer instruments. New technologies in image data processing and sea-ice tracking born out of these efforts have generated fresh insights into the dynamics and evolution of the Arctic and Southern Ocean sea ice covers.

Active and passive microwave data are used here in conjunction with meteorological analysis fields and in-situ buoy data to investigate the seasonal to interannual variability in bi-polar sea-ice conditions during the period 1978 - 1998. Supporting field data were acquired during Antarctic and Arctic experiments, including the 1992 Ice Station Weddell, and SHEBA, respectively. A variety of surface measurements were made during these experiments, along with deployment of drifting buoys. Together they contribute to the validation of satellite surface measurements, and the construction of optimally interpolated fields of ice drift tracking results.

Comparisons between satellite-derived, gridded ice-motion vectors and ECMWF/NCEP analyses indicate the large-scale response of sea-ice drift in the Arctic basin and Southern Ocean to atmospheric forcing on different time and space scales. For the first time, this presents the opportunity to assess the mass balance of the ice cover, and to quantify the freshwater redistribution term which ice advection represents. Recent developments of Lagrangian ice tracking permit precise quantification of the differential kinematics and thus opening and closing of the sea ice pack. Lagrangian calculations allow the thermodynamic growth in leads and salt flux to be more accurately quantified, together with development of an indirect assessment of ridging and the evolving ice thickness distribution within each grid cell. Arctic-wide results contribute to new insights into the sea-ice mass balance of the Arctic basin and the resultant interannual variability in the freshwater flux into the North Atlantic in response to the North Atlantic Oscillation.

Antarctic results show the spatial seasonal evolution in sea-ice dynamics in response to meteorological forcing, while at the same time identifying significant deficiencies of the Southern Ocean ECMWF and NCEP analysis products. Although large Gyre circulations such as in the Weddell and Ross Seas are forced primarily by the mean large-scale synoptic pressure field, ice drift on the continental shelves around Antarctica experiences significant high-frequency fluctuations in motion. High-frequency oscillations are driven by swift moving low-pressure systems, and tidal currents or inertial cycles (in shallow-water regions). Short time-scale drift fluctuations have significant impact on the ice cover and require that models accurately parameterize sub-daily processes in order to correctly simulate the ocean-atmosphere fluxes and the ice-growth driven salt flux over the shelf regions. The seasonality of drift patterns appear linked to the extent of the sea ice within the Weddell and Ross Sea basins and the translation of internal ice stresses through the pack ice. Examples are shown illustrating polynyas where divergence persists, in contrast to convergence zones in which large fractions of deformed ice are observed. High shear also helps delineate the axis of the Antarctic divergence in some parts of the

sea ice cover. In these regions, the separation between the coastal 'east wind drift' and ACC-dominated drift regimes are characterized by zonally-extended regions of intense shear.

Recent results from the Arctic and Antarctic illustrate that quantum leaps in our knowledge of key surface fluxes are about to be realized with existing and forthcoming satellite data sets. Future use of these sea ice products will identify the accuracy and limitations of these new approaches. Furthermore, their use in concert with judiciously deployed ocean instrument technologies such as instrumented buoys, ULS, current meters, and hydrographic moorings, and fine-resolution GCMs will insure their most accurate application in direct quantification of surface fluxes. Together satellite remote sensing datasets will undoubtedly contribute to a new understanding of the impact of the polar oceans on climate and the global thermohaline circulation.

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